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APPARATUS AND METHODS FOR FORMING CURVED LAMINATIONS

Field of Invention

The invention pertains to means for forming curved laminations. More particularly, the invention relates to adjustable and reusable tools and methods for producing building materials incorporating uniform, reproducible curved surfaces from laminated components.

Background of the Invention

Various types of tools and techniques have been developed for producing building materials having curved surfaces. U.S. Patent No. 3,444,568, issued to *Lerner* is directed to a lattice core/foundation for boat hulls. The lattice is formed using lateral members or strips and cross pieces that are positioned approximately normal to each other and mechanically locked together at points of intersection. The patent provides for the structure to have curves in which lay-ups or laminations may be applied.

U.S. Patent No. 5,106,290, issued to *Carver et al.*, is directed to an assembly data model tool system. The invention provides for a surface that includes a plurality of profile boards and at least one connecting board. The profile edges of the profile boards define the surface of the tool. A series of curved profile boards attach to connector boards to form a curved surface over which laminations may be assembled.

U.S. Patent No. 4,578,303, issued to *Kundinger et al.* describes a construction technique that involves preparation of an interleaved lattice structure or similar multi-level support structure over which a covering material is permanently installed. The curvature of the resulting construction is a result of this support structure.

U.S. Patent No. 5,150,507 issued to *Goela et al.* uses an interleaved, notched construction to produce flat or curved honeycomb structures. The interleaved ribs are coated with a SiC material to form a monolithic structure.

U.S. Patent No. 4,471,710 issued to *Brown* patent is directed to a method of manufacturing and applications of a building panel having a compound or complex curvature. The curved members are connected together by longitudinal members providing for a curved surface that is made from a plurality of strips of building material.

While other variations exist, the above-described inventions for forming curved laminations are typical of those encountered in the prior art. It is an objective of the present invention to provide a means for forming curved laminations that is repeatable and that can be preformed with a minimum of custom work. It is a further objective to provide a system for producing such laminations that includes standardized components that may be reused to produce laminations of differing curvature. It is a still further objective of the invention to provide means for producing laminations having base curves that differ from one end to the other. It is yet a further objective to provide means to produce laminations having surface curved in more than one plane.

While some of the objectives of the present invention are disclosed in the prior art, none of the inventions found include all of the requirements identified.

Summary of the Invention

The present invention addresses all of the deficiencies of prior art apparatus and methods for forming curved laminations and satisfies all of the objectives described above.

An apparatus for forming curved laminations providing the desired features may be constructed from the following components. A planar horizontal surface is provided, as is a first die board. The first die board has a planar lower surface, a first curved upper surface, a first predetermined thickness, first and second sides and first and second ends. A plurality of lamination support members is provided. The support members have parallel top and bottom surfaces, first and second sides, first and second ends and a second predetermined thickness.

When the planar lower surface of the first die board is located upon the horizontal surface and the lamination support members are located upon the first curved upper surface of the first die board with the bottom surface adjacent the second end of the lamination support members located upon the horizontal surface, the top surfaces of the lamination support members will reflect the first curved upper surface of the first die board above a point where the lamination support members contact the first upper surface and provide a curved surface for laminating veneer portions.

In a variant of the invention, a second die board is provided. The second die board has a planar lower surface, a second curved upper surface, a third predetermined thickness, first and second sides and first and second ends. When the planar lower surfaces of the first and second die boards are located upon the horizontal surface and the lamination support members are located upon the first and second curved upper surfaces of the first and second die boards, the top surfaces of the lamination support members will reflect the first and second curved upper surfaces of the first and second die boards and provide a curved surface for laminating veneer portions.

In a further variant, the lamination support members are cylindrical in cross-section. In still a further variant, the lamination support members are substantially rectangular in cross-

section. The first side of the lamination support member includes a rounded projecting tongue and the second side of the lamination support member includes a mating rounded, receiving notch. Adjacent lamination support members will fit more closely together while following the first curved upper surface of the first die board, thereby forming a smoother surface upon which veneer portions are laminated.

In another variant of the invention, an insulating sheet is provided. The insulating sheet is formed of thin, flexible, resilient material. The insulating sheet is located between top surfaces of the lamination support members and a lower surface of a veneer portion being laminated upon the lamination support members. When the insulating sheet is inserted between the lamination support members and the lower surface of a veneer portion indentations in a lamination resulting from contact with top surfaces of the lamination support members will be minimized.

In still another variant, a planar horizontal surface is provided, as is a first die board. The first die board has a planar lower surface, a first curved upper surface, a first predetermined thickness, first and second sides and first and second ends. A plurality of lamination support members is provided. The support members have parallel top and bottom surfaces, first and second sides, first and second ends, a fourth predetermined thickness and a first notch located upon the bottom surface and spaced inwardly from the first end. The first notch has first and second side walls and a first upper bearing surface. The first notch is sized and shaped to fit slidably over the first predetermined thickness of the first die board.

When the planar lower surface of the first die board is located upon the horizontal surface and the first notches of the lamination support members are located upon the first curved upper surface of the first die board with the bottom surface adjacent the second end of

the lamination support members located upon the horizontal surface, the top surfaces of the lamination support members will reflect the first curved upper surface of the first die board above a point where the first notches contact the first upper surface and provide a curved surface for laminating veneer portions.

In yet another variant, a second die board is provided. The second die board has a planar lower surface, a second curved upper surface, the first predetermined thickness, first and second sides and first and second ends. A second notch is provided. The second notch is located upon the bottom surface and is spaced inwardly from the second end of the lamination support members. The second notch has first and second side walls and a second upper bearing surface. The second notch is sized and shaped to fit slidably over the first predetermined thickness of the second die board.

When the planar lower surfaces of the first and second die boards are located upon the horizontal surface and the first and second notches of the lamination support members are located upon the first and second curved upper surfaces of the first and second die boards, the top surfaces of the lamination support members will reflect the first and second curved upper surfaces of the first and second die boards and provide a curved surface for laminating veneer portions.

In still another variant, an insulating sheet is provided. The insulating sheet is formed of thin, flexible, resilient material. The insulating sheet is located between top surfaces of the lamination support members and a lower surface of a veneer portion being laminated upon the lamination support members. When the insulating sheet is inserted between the lamination support members and the lower surface of a veneer portion indentations in a lamination

resulting from contact with top surfaces of the lamination support members will be minimized.

In still a further variant of the invention, the first upper bearing surface of the first notch includes a downward facing curve. The downward facing curve has its lowest point at a vertical centerline of the lamination support member. When the first notch of the lamination support members is located upon the first curved upper surface of the first die board, with the bottom surface adjacent the second end of the lamination support members located upon the horizontal surface, the top surfaces of the lamination support members will more accurately reflect the first curved upper surface of the first die board above a point where the downward facing curve of the first upper bearing surface of the first notch contacts the first curved upper surface and provide a curved surface for laminating veneer portions.

In another variant, the first and second upper bearing surfaces of the first and second notches include downward facing curves. The downward facing curves have their lowest points at a vertical centerline of the lamination support member. When the first and second notches of the lamination support members are located upon the first and second curved upper surfaces of the first and second die boards, the top surfaces of the lamination support members will more accurately reflect the first and second curved upper surfaces of the first and second die boards and provide a curved surface for laminating veneer portions.

In yet another variant, a series of closely spaced cuts extends orthogonally from the first side to the second side and from the top surface toward the bottom surface of the lamination support members. The cuts permit the top surfaces to assume a three-dimensional contoured configuration when a three-dimensional object having the configuration on an upper surface is placed between the horizontal surface and the bottom surface of the

lamination support members. When the object causes the lamination support members to bend upwardly, a surface having compound curves will be formed for laminating veneer portions.

In still another variant, the first curved upper surface of the first die board includes an upward facing curve extending from the first side to the second side of the first die board.

In yet another variant of the invention, the top surface of each lamination support member includes an upward facing curve extending from the first side to the second side of the member.

In a further variant, the first upper bearing surface of the first notch is formed as a portion of an orifice located at a first predetermined distance from the top surface of the lamination support member. The first and second side walls of the first notch extend upwardly from the bottom surface of the support member and intersect a lower portion of a perimeter of the orifice.

In still a further variant, the first upper bearing surface of the first notch includes a downward facing curve extending from the first side to the second side of the lamination support member. The downward facing curve has its lowest point at a vertical centerline of the lamination support member.

A method for forming curved laminations includes the following steps. Providing a planar horizontal surface. Preparing a first die board. The first die board has a planar lower surface, a first curved upper surface, a first predetermined thickness, first and second sides and first and second ends. The first curved upper surface reflects a desired curve for at least one end of a lamination. Providing a plurality of lamination support members. The support members have parallel top and bottom surfaces, first and second sides, first and second ends, a

second predetermined thickness. Positioning the lower planar surface of the first die board upon the horizontal surface.

Assembling the lamination support members upon the first die board and with the bottom surface adjacent the second end of the lamination support members located upon the horizontal surface. Providing an insulating sheet. The insulating sheet is formed of thin, flexible, resilient material and is designed to prevent indentations in a lamination resulting from contact with top surfaces of the lamination support members. Placing the insulating sheet upon the top surfaces of the lamination support members. Preparing at least two veneer portions. The veneer portions are sized and shaped to fit above the top surfaces of the lamination support members. Providing a glue layer between the veneer portions. Placing the veneer portions upon the insulating sheet. Applying pressure to an upper surface of a top veneer portion. Allowing the glue to dry and removing the laminated veneer portions from the insulating sheet.

A variant of the method for forming curved laminations includes the following steps. Providing a planar horizontal surface and preparing a first die board. The first die board has a planar lower surface, a first curved upper surface, a first predetermined thickness, first and second sides and first and second ends. The first curved upper surface reflects a desired curve for at least one end of a lamination. Preparing a second die board. The second die board has a planar lower surface, a second curved upper surface, a third predetermined thickness, first and second sides and first and second ends. The second curved upper surface reflects a desired curve for at least one end of a lamination.

Providing a plurality of lamination support members. The support members have parallel top and bottom surfaces, first and second sides, first and second ends and a second

predetermined thickness. Positioning the lower planar surfaces of the first and second die boards upon the horizontal surface with the first die board parallel to the second die board. The first die board is spaced from the second die board. Assembling the lamination support members upon the first and second die boards. Providing an insulating sheet. The insulating sheet is formed of thin, flexible, resilient material and is designed to prevent indentations in a lamination resulting from contact with top surfaces of the lamination support members. Placing the insulating sheet upon the top surfaces of the lamination support members.

Preparing at least two veneer portions. The veneer portions are sized and shaped to fit above the top surfaces of the lamination support members. Providing a glue layer between the veneer portions. Placing the veneer portions upon the insulating sheet. Applying pressure to an upper surface of a top veneer portion. Allowing the glue to dry and removing the laminated veneer portions from the insulating sheet.

A further variant of the method includes the following steps. Providing a planar horizontal surface. Preparing a first die board. The first die board has a planar lower surface, a first curved upper surface, a first predetermined thickness, first and second sides and first and second ends. The first curved upper surface reflecting a desired curve for at least one end of a lamination. Providing a plurality of lamination support members. The support members have parallel top and bottom surfaces, first and second sides, first and second ends and a fourth predetermined thickness.

A first notch is located upon the bottom surface of the support member and spaced inwardly from the first end. The first notch has first and second side walls and a first upper bearing surface. The first notch is sized and shaped to fit slidably over the first predetermined thickness of the first die board. Positioning the lower planar surface of the first die board

upon the horizontal surface. Assembling the lamination support members upon the first die board with the first notches engaging the first curved upper surface of the first die board and with the bottom surface adjacent the second end of the lamination support members located upon the horizontal surface. Providing an insulating sheet. The insulating sheet is formed of thin, flexible, resilient material and is designed to prevent indentations in a lamination resulting from contact with top surfaces of the lamination support members. Placing the insulating sheet upon the top surfaces of the lamination support members. Preparing at least two veneer portions, the veneer portions are sized and shaped to fit above the top surfaces of the lamination support members. Providing a glue layer between the veneer portions. Placing the veneer portions upon the insulating sheet. Applying pressure to an upper surface of a top veneer portion. Allowing the glue to dry and removing the laminated veneer portions from the insulating sheet.

Yet a further variant of the method includes the following steps. Providing a planar horizontal surface. Preparing a first die board. The first die board has a planar lower surface, a first curved upper surface, a first predetermined thickness, first and second sides and first and second ends. The first curved upper surface reflects a desired curve for at least one end of a lamination. Preparing a second die board. The second die board has a planar lower surface, a second curved upper surface, the first predetermined thickness, first and second sides and first and second ends. The second curved upper surface reflects a desired curve for at least one end of a lamination.

Providing a plurality of lamination support members. The support members have parallel top and bottom surfaces, first and second sides, first and second ends, a fourth predetermined thickness and first and second notches located upon the bottom surface and

spaced inwardly from the first end and second end, respectively. The first and second notches have first and second side walls and first and second upper bearing surfaces. The first and second notches are sized and shaped to fit slidably over the first predetermined thickness of the first and second die boards. Positioning the lower planar surfaces of the first and second die boards upon the horizontal surface with the first die board parallel to the second die board. The first die board is spaced from the second die board by a distance separating the first notch from the second notch. Assembling the lamination support members upon the first and second die boards with the first and second notches engaging the first and second curved upper surfaces of the first and second die boards.

Providing an insulating sheet. The insulating sheet is formed of thin, flexible, resilient material and is designed to prevent indentations in a lamination resulting from contact with top surfaces of the lamination support members. Placing the insulating sheet upon the top surfaces of the lamination support members. Preparing at least two veneer portions. The veneer portions are sized and shaped to fit above the top surfaces of the lamination support members. Providing a glue layer between the veneer portions. Placing the veneer portions upon the insulating sheet. Applying pressure to an upper surface of a top veneer portion. Allowing the glue to dry and removing the laminated veneer portions from the insulating sheet.

A further variant of the method for forming curved laminations includes the following steps. Applying pressure to the upper surface of the top veneer portion by inserting the apparatus for forming curved laminations together with the veneer portions with interleaved glue layer located upon the insulating sheet, located upon the top surfaces of the lamination support members, into a heavy duty, airtight plastic bag. Sealing the bag and evacuating the

air from the bag, thereby allowing atmospheric pressure to conform the veneer portions to the insulating sheet and the top surface of the lamination support members.

Another variant of the apparatus for forming curved laminations includes a desired lamination profile. The profile includes a planar baseline, and an upper curve. The baseline has a first end, a second end, and is comprised of a series of equal-sized increments. The upper curve, defines a height above the baseline for each increment of the baseline from the first end to the second end. A plurality of adjacent lamination support members is provided. The support members have parallel top and bottom surfaces, first and second sides, first and second ends and a fifth predetermined thickness equal to the equal-sized increment. Each of the adjacent lamination support members have a height equal to the height of the upper curve of the desired lamination profile above the baseline for one of the equal-sized increments. Means are provided for maintaining the adjacent lamination support members in parallel alignment to one another, thereby yielding a curved surface defined by the adjacent top surfaces of the adjacent lamination support members. The curved surface is suitable for laminating veneer portions.

A final variant of the method for forming curved laminations includes the following steps. Developing a desired lamination profile. The profile includes a planar baseline, and an upper curve. The baseline has a first end, a second end, and is comprised of a series of equal-sized increments. The upper curve defines a height above the baseline for each increment of the baseline from the first end to the second end. Providing a plurality of adjacent lamination support members. The support members have parallel top and bottom surfaces, first and second sides, first and second ends and a fifth predetermined thickness equal to the equal-sized increment. Each of the adjacent lamination support members has a height equal to the

height of the upper curve of the desired lamination profile above the baseline for one of the equal-sized increments. Maintaining the adjacent lamination support members in parallel alignment to one another, thereby yielding a curved surface defined by the adjacent top surfaces of the adjacent lamination support members. The curved surface is suitable for laminating veneer portions.

Providing an insulating sheet. The insulating sheet is formed of thin, flexible, resilient material and is designed to prevent indentations in a lamination resulting from contact with top surfaces of the adjacent lamination support members. Placing the insulating sheet upon the top surfaces of the adjacent lamination support members. Preparing at least two veneer portions. The veneer portions are sized and shaped to fit above the top surfaces of the adjacent lamination support members. Providing a glue layer between the veneer portions. Placing the veneer portions upon the insulating sheet. Applying pressure to an upper surface of a top veneer portion. Allowing the glue to dry and removing the laminated veneer portions from the insulating sheet.

Still another variant of the invention for forming curved laminations providing the desired features may be constructed from the following components. A planar horizontal surface is provided, as is a first die board. The first die board has a planar lower surface, a first curved upper surface, a first predetermined thickness, first and second sides and first and second ends. A plurality of lamination support members is provided. The support members have top and bottom surfaces, first and second sides, first and second ends and a second predetermined thickness.

When the planar lower surface of the first die board is located upon the horizontal surface and the lamination support members are located upon the first curved upper surface of

the first die board with the bottom surface adjacent the second end of the lamination support members located upon the horizontal surface, the top surfaces of the lamination support members will reflect the first curved upper surface of the first die board above a point where the lamination support members contact the first upper surface and provide a curved surface for laminating veneer portions.

In a further variant of the invention, a second die board is provided. The second die board has a planar lower surface, a second curved upper surface, a third predetermined thickness, first and second sides and first and second ends. When the planar lower surfaces of the first and second die boards are located upon the horizontal surface and the lamination support members are located upon the first and second curved upper surfaces of the first and second die boards, the top surfaces of the lamination support members will reflect the first and second curved upper surfaces of the first and second die boards and provide a curved surface for laminating veneer portions.

In still another variant, a planar horizontal surface is provided, as is a first die board. The first die board has a planar lower surface, a first curved upper surface, a first predetermined thickness, first and second sides and first and second ends. A plurality of lamination support members is provided. The support members have top and bottom surfaces, first and second sides, first and second ends, a fourth predetermined thickness and a first notch located upon the bottom surface and spaced inwardly from the first end. The first notch has first and second side walls and a first upper bearing surface. The first notch is sized and shaped to fit slidably over the first predetermined thickness of the first die board.

When the planar lower surface of the first die board is located upon the horizontal surface and the first notches of the lamination support members are located upon the first

curved upper surface of the first die board with the bottom surface adjacent the second end of the lamination support members located upon the horizontal surface, the top surfaces of the lamination support members will reflect the first curved upper surface of the first die board above a point where the first notches contact the first upper surface and provide a curved surface for laminating veneer portions.

In a final variant, a second die board is provided. The second die board has a planar lower surface, a second curved upper surface, the first predetermined thickness, first and second sides and first and second ends. A second notch is provided. The second notch is located upon the bottom surface and is spaced inwardly from the second end of the lamination support members. The second notch has first and second side walls and a second upper bearing surface. The second notch is sized and shaped to fit slidably over the first predetermined thickness of the second die board.

When the planar lower surfaces of the first and second die boards are located upon the horizontal surface and the first and second notches of the lamination support members are located upon the first and second curved upper surfaces of the first and second die boards, the top surfaces of the lamination support members will reflect the first and second curved upper surfaces of the first and second die boards and provide a curved surface for laminating veneer portions.

An appreciation of the other aims and objectives of the present invention and an understanding of it may be achieved by referring to the accompanying drawings and the detailed description of a preferred embodiment.

Description of the Drawings

Figure 1 is a perspective view of a first embodiment of the invention including a single die board;

Figure 2 is a perspective view of the **Figure 1** embodiment including a second die board;

Figure 3 is a perspective view of the **Figure 1** embodiment including cylindrical lamination support members;

Figure 4 is a side view of the **Figure 1** embodiment including lamination support members having a projecting tongue and a mating rounded, receiving notch;

Figure 5 is a side view of the **Figure 1** embodiment including an insulating sheet located above the lamination support members;

Figure 6 is a perspective view of a second embodiment of the invention including a single die board and notched lamination support members being assembled;

Figure 6A is a perspective view of the **Figure 6** embodiment as assembled;

Figure 7 is a perspective view of the second embodiment of the invention including a second die board and dual notched lamination support members being assembled;

Figure 7A is a perspective view of the **Figure 7** embodiment as assembled;

Figure 8 is a side view of the **Figure 7** embodiment including an insulating sheet located above the notched lamination support members;

Figure 9 is a perspective view of a notched lamination support member for use with the **Figure 6** embodiment including a downward facing curve on the first upper bearing surface of the first notch;

Figure 9A is a cross-sectional end view detail of the **Figure 9** support member taken along the line **9A-9A**;

Figure 10 is a perspective view of a notched lamination support member for use with the **Figure 7** embodiment including downward facing curves on the first and second upper bearing surfaces of the first and second notches;

Figure 11 is a perspective view of the **Figure 7** embodiment including means for producing laminations in a second plane;

Figure 11A is a perspective view of a lamination support member having a series of vertical slits extending from the top surface toward the bottom surface for use with the **Figure 11** embodiment;

Figure 12 is a perspective view of a die board having a curved upper surface;

Figure 13 is a perspective view of a lamination support member having a curved top surface;

Figure 14 is a perspective view of a lamination support member having the upper bearing surfaces of the first and second notches formed as a portion of an orifice located at a first predetermined distance from the top surface of the member;

Figure 15 is a perspective view of the **Figure 14** lamination support member including downward facing curves at the upper bearing surfaces;

Figure 15A is a cross-sectional end view detail of the **Figure 15** support member taken along the line **15A-15A**;

Figure 16 is a perspective view of the method of forming a curved lamination using the **Figure 3** embodiment and insulating sheet;

Figure 17 is a perspective view of the method of forming a curved lamination using the **Figure 2** embodiment and insulating sheet;

Figure 18 is a perspective view of the method of forming a curved lamination using the **Figure 6** embodiment and insulating sheet;

Figure 19 is a perspective view of the method of forming a curved lamination using the **Figure 7** embodiment and insulating sheet;

Figure 20 is a side view of the method of forming a curved lamination using the **Figure 7** embodiment and a sealable, flexible bag and vacuum pump to compress the laminations upon the lamination support members and insulating sheet;

Figure 21A is a plan view of a desired lamination profile;

Figure 21B is an end view of a series of lamination support members formed according to the desired lamination profile;

Figure 21C is an end view of the method of forming a curved lamination using the **Figure 21B** embodiment and insulating sheet;

Figure 22 is a perspective view of a first embodiment of the invention including a single die board and lamination support members having top and bottom surfaces that are not parallel;

Figure 23 is a perspective view of the **Figure 1** embodiment including a second die board and cylindrical lamination support members in the form of truncated cones;

Figure 24 is a perspective view of a second embodiment of the invention including a single die board and notched lamination support members having top and bottom surfaces that are not parallel; and

Figure 25 is a perspective view of the second embodiment of the invention including a second die board and dual notched lamination support members having top and bottom surfaces that are not parallel.

Detailed Description of the Preferred Embodiment

Figures 1-5 illustrate an apparatus **10** for forming curved laminations providing the desired features that may be constructed from the following components. As illustrated in **Figure 1**, a planar horizontal surface **14** is provided as is a first die board **18**. The first die board **18** has a planar lower surface **22**, a first curved upper surface **26**, a first predetermined thickness **30**, first **34** and second **38** sides and first **42** and second **46** ends. A plurality of lamination support members **50** is provided. The support members **50** have parallel top **54** and bottom **58** surfaces, first **62** and second **66** sides, first **70** and second **74** ends and a second predetermined thickness **78**.

When the planar lower surface **22** of the first die board **18** is located upon the horizontal surface **14** and the lamination support members **50** are located upon the first curved upper surface **26** of the first die board **18** with the bottom surface **58** adjacent the second end **46** of the lamination support members **50** located upon the horizontal surface **14**, the top surfaces **54** of the lamination support members **50** will reflect the first curved upper surface **26** of the first die board **18** above a point where the lamination support members **50** contact the first upper surface **26** and provide a curved surface **82** for laminating veneer portions(not shown).

In a variant of the invention, as illustrated in **Figure 2**, a second die board **86** is provided. The second die board **86** has a planar lower surface **90**, a second curved upper

surface **94**, a second predetermined thickness **98**, first **102** and second **106** sides and first **110** and second **114** ends. When the planar lower surfaces **22, 90** of the first **18** and second **86** die boards are located upon the horizontal surface **14** and the lamination support members **50** are located upon the first **26** and second **94** curved upper surfaces of the first **18** and second **86** die boards, the top surfaces **54** of the lamination support members **50** will reflect the first **26** and second **94** curved upper surfaces of the first **18** and second **86** die boards and provide a curved surface **118** for laminating veneer portions (not shown).

In a further variant, as illustrated in **Figure 3**, the lamination support members **50** are cylindrical in cross-section. In still a further variant, as illustrated in **Figure 4**, the lamination support members **50** are substantially rectangular in cross-section. The first side **62** of the lamination support member **50** includes a rounded projecting tongue **122** and the second side **66** of the lamination support member **50** includes a mating rounded, receiving notch **126**. Adjacent lamination support members **50** will fit more closely together while following the first curved upper surface **26** of the first die board **18**, thereby forming a smoother surface upon which veneer portions are laminated.

In another variant of the invention, as illustrated in **Figure 5**, an insulating sheet **130** is provided. The insulating sheet **130** is formed of thin, flexible, resilient material. The insulating sheet **130** is located between top surfaces **54** of the lamination support members **50** and a lower surface (not shown) of a veneer portion (not shown) being laminated upon the lamination support members **50**. When the insulating sheet **130** is inserted between the lamination support members **50** and the lower surface of a veneer portion indentations in a lamination resulting from contact with top surfaces **54** of the lamination support members **50** will be minimized.

In still another variant, as illustrated in **Figures 6** and **6A**, a planar horizontal surface **14** is provided as is a first die board **18**. The first die board **18** has a planar lower surface **22**, a first curved upper surface **26**, a first predetermined thickness **30**, first **34** and second **38** sides and first **42** and second **46** ends. A plurality of lamination support members **134** is provided. The support members **134** have parallel top **138** and bottom **142** surfaces, first **146** and second **150** sides, first **154** and second **158** ends, a fourth predetermined thickness **162** and a first notch **166** located upon the bottom surface **142** and spaced inwardly from the first end **154**. The first notch **166** has first **170** and second **174** side walls and a first upper bearing surface **178**. The first notch **166** is sized and shaped to fit slidably over the first predetermined thickness **30** of the first die board **18**.

When the planar lower surface **22** of the first die board **18** is located upon the horizontal surface **14** and the first notches **166** of the lamination support members **134** are located upon the first curved upper surface **26** of the first die board **18** with the bottom surface **142** adjacent the second end **158** of the lamination support members **134** located upon the horizontal surface **14**, the top surfaces **138** of the lamination support members **134** will reflect the first curved upper surface **26** of the first die board **18** above a point where the first notches **166** contact the first upper surface **26** and provide a curved surface **182** for laminating veneer portions.

In yet another variant, as illustrated in **Figures 7** and **7A**, a second die board **86** is provided. The second die board **86** has a planar lower surface **90**, a second curved upper surface **94**, the first predetermined thickness **30**, first **102** and second **106** sides and first **110** and second **114** ends. A second notch **186** is provided. The second notch **186** is located upon the bottom surface **142** and is spaced inwardly from the second end **150** of the lamination

support members **134**. The second notch **186** has first **190** and second **194** side walls and a second upper bearing surface **198**. The second notch **186** is sized and shaped to fit slidably over the first predetermined thickness **30** of the second die board **86**.

When the planar lower surfaces **22, 90** of the first **18** and second **86** die boards are located upon the horizontal surface **14** and the first **166** and second **186** notches of the lamination support members **134** are located upon the first **26** and second **94** curved upper surfaces of the first **18** and second **86** die boards, the top surfaces **138** of the lamination support members **134** will reflect the first **26** and second **94** curved upper surfaces of the first **18** and second **86** die boards and provide a curved surface **202** for laminating veneer portions.

In still another variant, as illustrated in **Figure 8**, an insulating sheet **130** is provided. The insulating sheet **130** is formed of thin, flexible, resilient material. The insulating sheet **130** is located between top surfaces **138** of the lamination support members **134** and a lower surface (not shown) of a veneer portion being laminated upon the lamination support members **134**. When the insulating sheet **130** is inserted between the lamination support members **134** and the lower surface of a veneer portion, indentations in a lamination resulting from contact with top surfaces **138** of the lamination support members **134** will be minimized.

In still a further variant of the invention, as illustrated in **Figures 9** and **9A**, the first upper bearing surface **178** of the first notch **166** includes a downward facing curve **206**. The downward facing curve **206** has its lowest point **210** at a vertical centerline **214** of the lamination support member **134**. When the first notch **166** of the lamination support members **134** is located upon the first curved upper surface **26** of the first die board **18**, with the bottom surface **58** adjacent the second end **46** of the lamination support members **134** located upon the horizontal surface **14**, the top surfaces **138** of the lamination support members **134** will

more accurately reflect the first curved upper surface **26** of the first die board **18** above a point where the downward facing curve **206** of the first upper bearing surface **178** of the first notch **166** contacts the first curved upper surface **26** and provide a curved surface (not shown) for laminating veneer portions.

In another variant, as illustrated in **Figure 10**, the first **178** and second **198** upper bearing surfaces of the first **166** and second **186** notches include downward facing curves **206**. The downward facing curves **206** have their lowest points **210** at a vertical centerline **214** of the lamination support member **134**. When the first **166** and second **186** notches of the lamination support members **134** are located upon the first **26** and second **94** curved upper surfaces of the first **18** and second **86** die boards, the top surfaces **138** of the lamination support members **134** will more accurately reflect the first **26** and second **94** curved upper surfaces of the first **18** and second **86** die boards and provide a curved surface (not shown) for laminating veneer portions.

In yet another variant, as illustrated in **Figures 11** and **11A**, a series of closely spaced cuts **218** extends orthogonally from the first side **146** to the second side **150** and from the top surface **138** toward the bottom surface **142** of the lamination support members **134**. The cuts **218** permit the top surfaces **138** to assume a three-dimensional contoured configuration **222** when a three-dimensional object **226** having the configuration **222** on an upper surface **230** is placed between the horizontal surface **14** and the bottom surface **142** of the lamination support members **134**. When the object **226** causes the lamination support members **134** to bend upwardly, a surface having compound curves **234** will be formed for laminating veneer portions.

In still another variant, as illustrated in **Figure 12**, the first curved upper surface **26** of the first die board **18** includes an upward facing curve **238** extending from the first side **34** to the second side **38** of the first die board **18**.

In yet another variant of the invention, as illustrated in **Figure 13**, the top surface **138** of each lamination support member **134** includes an upward facing curve **242** extending from the first side **146** to the second side **150** of the member **134**.

In a further variant, as illustrated in **Figure 14**, the first upper bearing surface **178** of the first notch **166** is formed as a portion of an orifice **246** located at a first predetermined distance **250** from the top surface **138** of the lamination support member **134**. The first **170** and second **174** side walls of the first notch **166** extend upwardly from the bottom surface **142** of the support member **134** and intersect a lower portion **254** of a perimeter **258** of the orifice **246**.

In still a further variant, as illustrated in **Figures 15** and **15A**, the first upper bearing surface **178** of the first notch **166** includes a downward facing curve **262** extending from the first side **146** to the second side **150** of the lamination support member **134**. The downward facing curve **262** has its lowest point **266** at a vertical centerline **214** of the lamination support member **134**.

A method for forming curved laminations **270**, as illustrated in **Figure 16**, includes the following steps. Providing a planar horizontal surface **14**. Preparing a first die board **18**. The first die board **18** has a planar lower surface **22**, a first curved upper surface **26**, a first predetermined thickness **30**, first **34** and second **38** sides and first **42** and second **46** ends. The first curved upper surface **26** reflects a desired curve for at least one end of a lamination. Providing a plurality of lamination support members **50**. The support members **50** have

parallel top **54** and bottom **58** surfaces, first **62** and second **66** sides, first **70** and second **74** ends, a second predetermined thickness **78**. Positioning the lower planar surface **22** of the first die board **18** upon the horizontal surface **14**.

Assembling the lamination support members **50** upon the first die board **18** and with the bottom surface **58** adjacent the second end **74** of the lamination support members **50** located upon the horizontal surface **14**. Providing an insulating sheet **130**. The insulating sheet **130** is formed of thin, flexible, resilient material and is designed to prevent indentations in a lamination resulting from contact with top surfaces **54** of the lamination support members **50**. Placing the insulating sheet **130** upon the top surfaces **54** of the lamination support members **50**. Preparing at least two veneer portions **274**. The veneer portions **274** are sized and shaped to fit above the top surfaces **54** of the lamination support members **50**. Providing a glue layer **278** between the veneer portions **274**. Placing the veneer portions **274** upon the insulating sheet **130**. Applying pressure **282** to an upper surface **286** of a top veneer portion **290**. Allowing the glue **278** to dry and removing the laminated veneer portions **274** from the insulating sheet **130**.

A variant of the method for forming curved laminations **294**, as illustrated in **Figure 17**, includes the following steps. Providing a planar horizontal surface **14** and preparing a first die board **18**. The first die board **18** has a planar lower surface **22**, a first curved upper surface **26**, a first predetermined thickness **30**, first **34** and second **38** sides and first **42** and second **46** ends. The first curved upper surface **26** reflects a desired curve for at least one end of a lamination. Preparing a second die board **86**. The second die board **86** has a planar lower surface **90**, a second curved upper surface **94**, a third predetermined thickness **98**, first **102** and

second **106** sides and first **110** and second **114** ends. The second curved upper surface **94** reflects a desired curve for at least one end of a lamination.

Providing a plurality of lamination support members **50**. The support members **50** have parallel top **54** and bottom **58** surfaces, first **62** and second **66** sides, first **70** and second **74** ends and a second predetermined thickness **78**. Positioning the lower planar surfaces **22, 90** of the first **18** and second **86** die boards upon the horizontal surface **14** with the first die board **18** parallel to the second die board **86**. The first die board **18** is spaced from the second die board **86**. Assembling the lamination support members **50** upon the first **18** and second **86** die boards. Providing an insulating sheet **130**. The insulating sheet **130** is formed of thin, flexible, resilient material and is designed to prevent indentations in a lamination resulting from contact with top surfaces **54** of the lamination support members **50**. Placing the insulating sheet **130** upon the top surfaces **54** of the lamination support members **50**.

Preparing at least two veneer portions **274**. The veneer portions **274** are sized and shaped to fit above the top surfaces **54** of the lamination support members **50**. Providing a glue layer **278** between the veneer portions **274**. Placing the veneer portions **274** upon the insulating sheet **130**. Applying pressure **282** to an upper surface **286** of a top veneer portion **290**. Allowing the glue **278** to dry and removing the laminated veneer portions **274** from the insulating sheet **130**.

A further variant of the method **298**, as illustrated in **Figure 18**, includes the following steps. Providing a planar horizontal surface **14**. Preparing a first die board **18**. The first die board **18** has a planar lower surface **22**, a first curved upper surface **26**, a first predetermined thickness **30**, first **34** and second **38** sides and first **42** and second **46** ends. The first curved upper surface **26** reflecting a desired curve for at least one end of a lamination. Providing a

plurality of lamination support members **134**. The support members **134** have parallel top **138** and bottom **142** surfaces, first **146** and second **150** sides, first **154** and second **158** ends and a fourth predetermined thickness **162**.

A first notch **166** is located upon the bottom surface **142** of the support member **134** and spaced inwardly from the first end **154**. The first notch **166** has first **170** and second **174** side walls and a first upper bearing surface **178**. The first notch **166** is sized and shaped to fit slidably over the first predetermined thickness **30** of the first die board **18**. Positioning the lower planar surface **22** of the first die board **18** upon the horizontal surface **14**. Assembling the lamination support members **134** upon the first die board **18** with the first notches **166** engaging the first curved upper surface **26** of the first die board **18** and with the bottom surface **142** adjacent the second end **158** of the lamination support members **134** located upon the horizontal surface **14**. Providing an insulating sheet **130**. The insulating sheet **130** is formed of thin, flexible, resilient material and is designed to prevent indentations in a lamination resulting from contact with top surfaces **138** of the lamination support members **134**. Placing the insulating sheet **130** upon the top surfaces **138** of the lamination support members **134**. Preparing at least two veneer portions **274**, the veneer portions **274** are sized and shaped to fit above the top surfaces **138** of the lamination support members **134**. Providing a glue layer **278** between the veneer portions **274**. Placing the veneer portions **274** upon the insulating sheet **130**. Applying pressure **282** to an upper surface **286** of a top veneer portion **290**. Allowing the glue **278** to dry and removing the laminated veneer portions **274** from the insulating sheet **130**.

Yet a further variant of the method **302**, as illustrated in **Figure 19**, includes the following steps. Providing a planar horizontal surface **14**. Preparing a first die board **18**. The

first die board **18** has a planar lower surface **22**, a first curved upper surface **26**, a first predetermined thickness **30**, first **34** and second **38** sides and first **42** and second ends **46**. The first curved upper surface **26** reflects a desired curve for at least one end of a lamination. Preparing a second die board **86**. The second die board **86** has a planar lower surface **90**, a second curved upper surface **94**, the first predetermined thickness **30**, first **102** and second **106** sides and first **110** and second **114** ends. The second curved upper surface **94** reflects a desired curve for at least one end of a lamination.

Providing a plurality of lamination support members **134**. The support members **134** have parallel top **138** and bottom **142** surfaces, first **146** and second **150** sides, first **154** and second **158** ends, a fourth predetermined thickness **162** and first **166** and second **186** notches located upon the bottom surface **142** and spaced inwardly from the first end **154** and second **158** end, respectively. The first **166** and second **186** notches have first **170, 190** and second **174, 194** side walls and first **178** and second **198** upper bearing surfaces. The first **166** and second **186** notches are sized and shaped to fit slidably over the first predetermined thickness **30** of the first **18** and second **86** die boards. Positioning the lower planar surfaces **22, 90** of the first **18** and second **86** die boards upon the horizontal surface **14** with the first die board **18** parallel to the second die board **86**. The first die board **18** is spaced from the second die board **86** by a distance **306** separating the first notch **166** from the second notch **186**. Assembling the lamination support members **134** upon the first **18** and second **86** die boards with the first **166** and second **186** notches engaging the first **26** and second **94** curved upper surfaces of the first **18** and second **86** die boards.

Providing an insulating sheet **130**. The insulating sheet **130** is formed of thin, flexible, resilient material and is designed to prevent indentations in a lamination resulting from contact

with top surfaces **138** of the lamination support members **134**. Placing the insulating sheet **130** upon the top surfaces **138** of the lamination support members **134**. Preparing at least two veneer portions **274**. The veneer portions **274** are sized and shaped to fit above the top surfaces **138** of the lamination support members **134**. Providing a glue layer **278** between the veneer portions **274**. Placing the veneer portions **274** upon the insulating sheet **130**. Applying pressure **282** to an upper surface **286** of a top veneer portion **290**. Allowing the glue **278** to dry and removing the laminated veneer portions **274** from the insulating sheet **130**.

A further variant of the method for forming curved laminations **306**, as illustrated in **Figure 20**, includes the following steps. Applying pressure **282** to the upper surface **286** of the top veneer portion **290** by inserting the apparatus for forming curved laminations **302** together with the veneer portions **274** with interleaved glue layer **278** located upon the insulating sheet **130**, located upon the top surfaces **138** of the lamination support members **134**, into a heavy duty, airtight plastic bag **310**. Sealing the bag **310** and evacuating the air **314** from the bag **310**, thereby allowing atmospheric pressure **282** to conform the veneer portions **274** to the insulating sheet **130** and the top surface **138** of the lamination support members **134**.

A final variant of the apparatus for forming curved laminations, as illustrated in **Figures 21A, 21B** and **21C**, includes a desired lamination profile **322**. The profile **322** includes a planar baseline **326**, and an upper curve **330**. The baseline **326** has a first end **334**, a second end **338**, and is comprised of a series of equal-sized increments **342**. The upper curve **330**, defines a height **346** above the baseline **326** for each increment **342** of the baseline **326** from the first end **334** to the second end **338**. A plurality of adjacent lamination support members **350** is provided. The support members **350** have parallel top **354** and bottom **358**

surfaces, first **362** and second **366** sides, first **370** and second **374** ends and a fifth predetermined thickness **378** equal to the equal-sized increment **342**. Each of the adjacent lamination support members **350** has a height **382** equal to the height **346** of the upper curve **330** of the desired lamination profile **322** above the baseline **326** for one of the equal-sized increments **342**. Means **386** are provided for maintaining the adjacent lamination support members **350** in parallel alignment to one another, thereby yielding a curved surface **390** defined by the adjacent top surfaces **354** of the adjacent lamination support members **350**. The curved surface **390** is suitable for laminating veneer portions.

A final variant of the method for forming curved laminations **394**, as illustrated in **Figures 21A, 21B** and **21C**, includes the following steps. Developing a desired lamination profile **322**. The profile **322** includes a planar baseline **326**, and an upper curve **330**. The baseline **326** has a first end **334**, a second end **338**, and is comprised of a series of equal-sized increments **342**. The upper curve **330** defines a height **346** above the baseline **326** for each increment **342** of the baseline **326** from the first end **334** to the second end **338**. Providing a plurality of adjacent lamination support members **350**. The support members **350** have parallel top **354** and bottom **358** surfaces, first **362** and second **366** sides, first **370** and second **374** ends and a fifth predetermined thickness **378** equal to the equal-sized increment **342**. Each of the adjacent lamination support members **350** has a height **382** equal to the height **346** of the upper curve **330** of the desired lamination profile **322** above the baseline **326** for one of the equal-sized increments **342**. Maintaining the adjacent lamination support members **350** in parallel alignment to one another, thereby yielding a curved surface **390** defined by the adjacent top surfaces **354** of the adjacent lamination support members **350**. The curved surface **390** is suitable for laminating veneer portions.

Providing an insulating sheet **130**. The insulating sheet **130** is formed of thin, flexible, resilient material and is designed to prevent indentations in a lamination resulting from contact with top surfaces **354** of the adjacent lamination support members **350**. Placing the insulating sheet **130** upon the top surfaces **354** of the lamination support members **350**. Preparing at least two veneer portions **274**. The veneer portions **274** are sized and shaped to fit above the top surfaces **354** of the lamination support members **350**. Providing a glue layer **278** between the veneer portions **274**. Placing the veneer portions **274** upon the insulating sheet **130**. Applying pressure **282** to an upper surface **286** of a top veneer portion **290**. Allowing the glue **278** to dry and removing the laminated veneer portions **274** from the insulating sheet **130**.

Figures 22-25 illustrate an apparatus **10** for forming curved laminations providing the desired features that may be constructed from the following components. As illustrated in **Figure 22**, a planar horizontal surface **14** is provided as is a first die board **18**. The first die board **18** has a planar lower surface **22**, a first curved upper surface **26**, a first predetermined thickness **30**, first **34** and second **38** sides and first **42** and second **46** ends. A plurality of lamination support members **52** is provided. The support members **52** have top **56** and bottom **60** surfaces, first **62** and second **66** sides, first **70** and second **74** ends and a second predetermined thickness **78**.

When the planar lower surface **22** of the first die board **18** is located upon the horizontal surface **14** and the lamination support members **52** are located upon the first curved upper surface **26** of the first die board **18** with the bottom surface **60** adjacent the second end **46** of the lamination support members **52** located upon the horizontal surface **14**, the top surfaces **56** of the lamination support members **52** will reflect the first curved upper surface **26** of the first die board **18** above a point where the lamination support members **52** contact the

first upper surface **26** and provide a curved surface **84** for laminating veneer portions(not shown).

In a variant of the invention, as illustrated in **Figure 23**, a second die board **86** is provided. The second die board **86** has a planar lower surface **90**, a second curved upper surface **94**, a second predetermined thickness **98**, first **102** and second **106** sides and first **110** and second **114** ends. When the planar lower surfaces **22, 90** of the first **18** and second **86** die boards are located upon the horizontal surface **14** and the lamination support members **52** are located upon the first **26** and second **94** curved upper surfaces of the first **18** and second **86** die boards, the top surfaces **56** of the lamination support members **52** will reflect the first **26** and second **94** curved upper surfaces of the first **18** and second **86** die boards and provide a curved surface **120** for laminating veneer portions (not shown).

In still another variant, as illustrated in **Figure 24**, a planar horizontal surface **14** is provided as is a first die board **18**. The first die board **18** has a planar lower surface **22**, a first curved upper surface **26**, a first predetermined thickness **30**, first **34** and second **38** sides and first **42** and second **46** ends. A plurality of lamination support members **136** is provided. The support members **136** have top **140** and bottom **144** surfaces, first **146** and second **150** sides, first **154** and second **158** ends, a fourth predetermined thickness **162** and a first notch **166** located upon the bottom surface **142** and spaced inwardly from the first end **154**. The first notch **166** has first **170** and second **174** side walls and a first upper bearing surface **178**. The first notch **166** is sized and shaped to fit slidably over the first predetermined thickness **30** of the first die board **18**.

When the planar lower surface **22** of the first die board **18** is located upon the horizontal surface **14** and the first notches **166** of the lamination support members **136** are

located upon the first curved upper surface **26** of the first die board **18** with the bottom surface **144** adjacent the second end **158** of the lamination support members **136** located upon the horizontal surface **14**, the top surfaces **140** of the lamination support members **136** will reflect the first curved upper surface **26** of the first die board **18** above a point where the first notches **166** contact the first upper surface **26** and provide a curved surface **184** for laminating veneer portions.

In a final variant, as illustrated in **Figure 25**, a second die board **86** is provided. The second die board **86** has a planar lower surface **90**, a second curved upper surface **94**, the first predetermined thickness **30**, first **102** and second **106** sides and first **110** and second **114** ends. A second notch **186** is provided. The second notch **186** is located upon the bottom surface **144** and is spaced inwardly from the second end **150** of the lamination support members **136**. The second notch **186** has first **190** and second **194** side walls and a second upper bearing surface **198**. The second notch **186** is sized and shaped to fit slidably over the first predetermined thickness **30** of the second die board **86**.

When the planar lower surfaces **22, 90** of the first **18** and second **86** die boards are located upon the horizontal surface **14** and the first **166** and second **186** notches of the lamination support members **136** are located upon the first **26** and second **94** curved upper surfaces of the first **18** and second **86** die boards, the top surfaces **140** of the lamination support members **136** will reflect the first **26** and second **94** curved upper surfaces of the first **18** and second **86** die boards and provide a curved surface **204** for laminating veneer portions.

The apparatus **10** and methods **270, 294, 298, 302, 306, 318** and **394** for forming curved laminations has been described with reference to particular embodiments. Other

modifications and enhancements can be made without departing from the spirit and scope of the claims that follow.